of the unit are respectively (1) of the same species, (2) of different species but of the same growth forms and of similar aspect, and (3) of different species and various growth forms presenting different series of aspects but united into an ecological unit in a single habitat by fixed correlation. This last grade of synusium corresponds very nearly with the "association" of most authors. Similar synusia are grouped as "isocies." For the topographical unit he adopts the word "biocoenose" (or biocoenosium), and uses it for the vegetation of a unit habitat. Biocoenosia of different regions which are compounded of isocies are called "isocoenosia."

The author rejects all attempts to classify vegetation units upon dynamic lines. He also gives a new classification of life forms, based largely upon the RAUNKIAER system, but more extended and including animals. It is safe to predict that such revolutionary changes as those urged by GAMS, even if they are logically conceived, will not be acceptable to the ecologists of America, and, judging from the criticism of the scheme by PAVILLARD (1919), they will meet with no greater favor in France.—GEO. D. FULLER.

Statistical methods in ecology.—It seems appropriate that from among the students of that father of modern ecology, EUGENE WARMING, should come a leader of perhaps the most promising line of advance in the ecology of today. RAUNKIAER more than any other has opened the way for the introduction of quantitative methods in the study of vegetation. His method of comparing the floras of different regions by means of a numerically expressed biological spectrum,[8] and of evaluating the mesophytism of a habitat by leaf classes,[9] have been noted in this journal. The latter method of estimating vegetation was made more familiar to American ecologists by the translation of FULLER and BAKKE,[10] who also included in their article a summary of a statistical method that had been familiar to Danish readers for some years.[11]

In a more recent article RAUNKIAER[12] has summarized the material of his former contributions, and has been able to show something of their applications to the solution of ecological problems. His statistical or valence method consists in determining the relative abundance of the different species composing a plant community of definitely limited extent, called by him a "formation," although more nearly equivalent to an association as understood by American ecologists. This determination is made by taking a census of a

[8] BOT. GAZ. **51**:309–310. 1911. [9] BOT. GAZ. **63**:242. 1917.

[10] FULLER, GEO. D., and BAKKE, A. L., Raunkiaer's life-forms, leaf-size classes, and statistical methods. Plant World **21**:25–37, 57–63. *fig. 1*. 1918.

[11] RAUNKIAER, C., Formations undersgelse og Formationsstatistik. Bot. Tidskr. **30**:20–132. 1909.

———, Om Valensmetoden. Bot. Tidskr. **34**:304–311. 1917.

[12] ———, Recherches statistiques sur les formations végétales. Det. Kgl. Danske Videnskabernes Selskab. Biol. Meddeleser. I **3**: pp. 80. *figs. 3*. 1918.

number (25–50) of small unit areas of the vegetation, selected at random or according to fixed plans, and outlined by the revolution of a metal radius of determined length attached to a walking stick.[13] The convenient size of these unit areas appears to be 0.1 sq. m., and the frequency with which a given species appears in such areas determines its valence, frequency percentage, or frequency coefficient. Emphasis is placed upon the fact that in an undisturbed area the vegetation will eventually come to a practically complete equilibrium with the factors of the habitat, and will be composed of the species of the region best fitted to exist under such conditions. RAUNKIAER therefore defines his "formation" as "essentially homogeneous from a floristic point of view," that is, homogeneous as to the dominant species or the species showing the highest frequency coefficients. Such a statistical method permits the quantitative comparison of similar plant communities and their more exact delimination.

It is interesting to note as the results of the use of such statistical methods, principally the examination of many plant communities involving the determination of over 8000 coefficients, that 55 per cent of the species have coefficients ranging from 1 to 20, 15 per cent from 81 to 100, 14 per cent from 21 to 40, 9 per cent from 61 to 80, and 3 per cent from 41 to 60. In other words, the least frequent species in the communities studied were most numerous, while the most frequent came second in order of number of species, with a much smaller number showing moderate abundance. These phenomena the author expresses in the form of a law. "In a formation in a relative state of equilibrium what allows one or more species to prosper at the expense of their neighbors is the fact that the dominant species are better adapted to live under the conditions existing within the formation of which they are a part and by their community life ('concurrence vitale') they prevent the other species from equaling them in frequency. But however well equipped they may be for such community life, they are not able to prevent other species, widely disseminated but fewer in individuals, from entering the formation and occupying portions that for any reason whatever may have been left unoccupied by the dominant species. Thus we see that there is a much larger number of the least frequent species."

For the further analysis of vegetation RAUNKIAER describes a method of arriving at the area occupied by each species in the community. This is accomplished by the study of unit areas similar to those employed in the determination of frequency; indeed the two could be done simultaneously. To assist in readily determining the portion of the area occupied by the areal parts of a species he adds a series of radii of determined length to the one already affixed at right angles to the walking stick. These are so spaced that they divide the circular unit area into fifths and tenths, so that by their aid

[13] RAUNKIAER, C., Measuring apparatus for investigations of plant formations. Bot. Tidskr. 33:45–48. 1912.

the observer is easily able to estimate 10 different degrees of covering. From a record of the numbers representing these degrees of covering the areal percentages of the different species are readily established.

A summary of the methods employed, and a classification of vegetation upon the basis of life-forms and leaf-sizes, completes an article rich in suggestions to the ecologist seeking more accurate methods.—GEO. D. FULLER.

Susceptibility gradients.—Following his demonstration of axial metabolic gradients in animals and their relation to the course of development and individuation, CHILD entered upon a study of axiate plants, particularly the algae. His first paper[14] on axial gradients in algae appeared several years ago. His interesting and valuable observations[15] have been extended to include a considerable number of new forms, and the results are sufficiently uniform to warrant the general conclusion that plants and animals are essentially similar in respect to these axial susceptibility gradients.

Twenty-five species have been studied, 14 of which were considered in the earlier paper, and all of them show an axial gradient in susceptibility to injury and death from such agents as KCN, alcohol, ether, HCl, $HgCl_2$, $CuSO_4$, neutral red, temperature, etc. When killing concentrations are used, death occurs first in the apical region and proceeds basipetally in each axis. The susceptibility gradient is a general indicator of metabolic rates, death occurring soonest in the most active protoplasm. The susceptibility gradient is rather easily altered or reversed by external conditions, by advancing age, physiological isolation of cells and branches, and other factors. The ease with which such reversals occur indicates in some degree the sensitiveness of species.

He finds[16] that the unicellular and multicellular hairs, either branched or unbranched, which occur on some algae, possess the same kind of axial gradients as the main axis. In such forms as *Fucus* and *Castagnea*, in which the hairs have basal growth, the gradient is acropetal; but whenever the hairs grow apically the normal gradient is basipetal. Reversals may be induced in these hairs, also, especially with low concentrations of the susceptibility reagents. In some cases the agent may reverse the susceptibility to itself, or one agent may reverse the susceptibility to another agent. These results indicate clearly that hairs represent physiological axes, and the gradient of susceptibility appears to be one of the aspects of physiological polarity in all axes. When the axial gradients are reversed, these hairs often separate into their component cells, or the hairs drop from the main axes. Loss of hairs in laboratory material

[14] CHILD, C. M., Axial susceptibility gradients in algae. BOT. GAZ. **62**:89–114. 1916.

[15] ———, Further observations on axial susceptibility gradients in algae. Biol. Bull. **31**:419–440. 1916.

[16] ———, Susceptibility gradients in the hairs of certain marine algae. Biol. Bull. **32**:75–92. 1917.